AIRS Version 3.0
L2 Data Release Documentation

Version 1.2

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Introduction

The Atmospheric Infrared Sounder (AIRS) instrument suite is designed to measure the Earth's atmospheric water vapor and temperature profiles on a global scale. It is comprised of a space-based hyperspectral infrared instrument (AIRS) and two multichannel microwave instruments, the Advanced Microwave Sounding Unit (AMSU-A) and the Humidity Sounder for Brazil (HSB). The AIRS instrument suite is one of several instruments onboard the Earth Observing System (EOS) Aqua spacecraft launched May 4, 2002.

The HSB instrument ceased operation on February 5, 2003. At the time of this writing, investigations into the possibility of recovering the instrument continue and there will be periodic attempts to reactivate it. The chance of success is deemed small.

Operational L1B and L2 Products of the AIRS/AMSU/HSB instrument suite on the EOS Aqua spacecraft are now available for use by the general public. They can be accessed on the web at the URLs:

EOS Data Gateway	http://eos.nasa.gov/imswelcome
GSFC DAAC Data Pool	http://daac.gsfc.nasa.gov/data/datapool/AIRS_DP
GSFC DAAC WHOM	http://daac.gsfc.nasa.gov/data/dataset/AIRS

These data are in the standard HDF-EOS v4 swath format. See

http://hdf.ncsa.uiuc.edu/rel4links.html

http://hdfeos.gsfc.nasa.gov/hdfeos/index.cfm

Only those for which the RetQAFlag is set to zero should be considered for study. Please read the **RetQAFlag** documentation available at the link:

V3.0_RetQAFlag.pdf

All data are released to the public, but only the AIRS and Visible/Near IR radiances are provisionally validated. Please read the disclaimer document:

V3.0_Data_Disclaimer.pdf

The Level 2 retrieval products are a beta release only in the case of those data that satisfy the following conditions

- Low Latitude (within the latitude range 40° South to 40° North)
- Ocean (land fraction in the AMSU field of view is less than 0.01)
- Retrieved SST agrees with NCEP analysis to within 3.0 K
- Sun glint avoided (glint distance greater than 200 km)
- Full retrieval (MW-Only, FIRST and FINAL stages all acceptable)

Only retrievals satisfying these conditions should be studied. Researchers can easily limit their selection of Level 2 data products to those satisfying these conditions by using the RetQAFlag swath data field in L2 Products. **All fields of view whose RetQAFlag is zero satisfy these criteria.**

The initial report covering the validation of the AIRS/AMSU/HSB products using ECMWF and NCEP reanalysis, operational buoys, operational radiosondes and AIRS-dedicated radiosondes and other dedicated observations also defines "**Provisional**", "**Beta**" and "**Validated**" states for data and is available at the link:

V3.0_Validation_Report.pdf

Also see the paper:

Fetzer, E., L. McMillin, D. Tobin, M. Gunson, H. H. Aumann, W. W. McMillan, D. Hagan, M. Hofstadter, J. Yoe, D. Whiteman, R. Bennartz, J. Barnes, H. Vömel, V. Walden, M. Newchurch, P. Minnett, R. Atlas, F. Schmidlin, E. T. Olsen, M. D. Goldberg, Sisong Zhou, HanJung Ding and H. Revercomb, "AIRS/AMSU/HSB Validation", *IEEE Trans. Geosci. Remote Sensing*, vol. 41, pp. 418-431, Feb. 2003.

The L1B data include geolocated, calibrated observed radiances, Quality Assessment (QA) data and global browse images. The radiances are well calibrated; however, not all QA data have been validated.

The L2 data include geolocated, calibrated cloud-cleared radiances and 2-dimensional and 3-dimensional retrieved physical quantities (e.g., surface properties and temperature, moisture and ozone profiles throughout the atmosphere). Global browse images are also included. Each product granule contains 6 minutes of data. Thus there are 240 granules of each product produced every day.

A complete description of the contents of the product files may be found in the companion document titled "**AIRS Version 3.0 Released Files Description**". A PDF file containing Version 1.0 of this document (JPL D-26381), dated June 2003, is available at the link:

V3.0_Release_ProcFileDesc.pdf

The document provides for each product:

- Dimensions for use in HDF-EOS swath fields (name, value, explanation)
- Geolocation fields (name, explanation)
- Attributes (name, type, extra dimensions, explanation)
- Along-track data fields (name, type, extra dimensions, explanation)
- Swath data fields (name, type, extra dimensions, explanation)
- Special AIRS types for engineering data fields (name, type, explanation)

It also provides the product file naming and local granule identification (LGID) conventions used in the identifier portion of the EOSDIS Core System (ECS) and a table of all current Science, Engineering and Browse Products (L1A, L1B and L2).

Descriptions of the data products provided in that document and instrument and data features provided here are limited to the V3.0 released data set. For additional information, please consult the AIRS public web site:

AIRS Public Web site	http://www.jpl.nasa.gov/airs.

Additional information may be accessed at the following web sites:

AIRS Data Support	http://daac.gsfc.nasa.gov/atmodyn/airs/.
Aqua AIRS Science	http://www.aqua.nasa.gov/AIRS/airs_science.html
AIRS ATBDs	Algorithm_Theoretical_Basis_Docs

Instrument Description and Status

Overview

The AIRS/AMSU/HSB instrument suite has been constructed to obtain atmospheric temperature profiles to an accuracy of 1 K for every 1 km layer in the troposphere and an accuracy of 1 K for every 4 km layer in the stratosphere up to an altitude of 40 km. The temperature profile accuracy in the troposphere will match that achieved by radiosondes launched from ground stations. The advantage of the AIRS suite in orbit is the provision of rapid global coverage. Radiosonde coverage of the Earth's oceans is practically nonexistent. In conjunction with the temperature profiles, the AIRS instrument suite will obtain humidity profiles to an accuracy of 10% in 2 km layers from the surface to the tropopause.

Description of Instruments

The Aqua Instrument Page provides guides to the instruments, including quicktime animations that illustrate their operation:

Aqua AIRS Instrument	http://www.aqua.nasa.gov/AIRS3.html
Aqua AMSU Instrument	http://www.aqua.nasa.gov/AMSU3.html
Aqua HSB Instrument	http://www.aqua.nasa.gov/HSB3.html

AIRS

The AIRS infrared spectrometer acquires 2378 spectral samples at resolutions, $\lambda/\Delta\lambda$, ranging from 1086 to 1570, in three bands: 3.74 μm to 4.61 μm, 6.20 μm to 8.22 μm, and 8.8 μm to 15.4 μm. A 360 degree rotation of the scan mirror generates a cross-track Earth-scene scan line of IR data every 2.667 seconds. The spatial resolution at nadir is 13.5 km. This instrument provides fine vertical scale resolution soundings of atmospheric temperature and water vapor, and integrated column burden for trace gases. Cold space-views for calibration of data are taken at the beginning and end of the Earth-scene when the mirror sweeps through space-view scenes.

The IR focal plane is cooled to 60 K by a Stirling/pulse tube cryocooler. The scan mirror operates at approximately 265 K due to radiative coupling to the Earth and space and to the 150 K IR spectrometer. Cooling of the IR optics and detectors is necessary to achieve the required instrument sensitivity.

AIRS VIS/NIR

The Visible/Near-IR (VIS/NIR) photometer contains four spectral bands, each with nine pixels along track, with a 0.185 degree instantaneous field-of-view (FOV). It is boresighted to the IR spectrometer to allow simultaneous measurements of the visible and infrared scene. The VIS/NIR photometer uses optical filters to define four spectral bands in the 400 nm to 1000 nm region. The VIS/NIR detectors are not cooled and operate in the 293 K to 300 K ambient temperature range of the instrument housing. The spatial resolution at nadir is 2.3 km. The primary function of the AIRS VIS/NIR channels is to provide diagnostic support to the infrared retrievals: setting flags that warn of the presence of low-clouds or highly variable surface features within the infrared FOV.

AMSU-A

The AMSU-A microwave multichannel radiometer consists of two physically separate units, AMSU-A1 and AMSU-A2. Together they have 15 channels, measuring radiation in the frequency span of 23 GHz to 90 GHz. Twelve channels (between 50 GHz and 60 GHz) are predominantly used for atmospheric temperature sounding. The remaining three channels (24 GHz, 31 GHz and 89 GHz) are predominantly used for atmospheric water vapor sounding. The rotating scanning mirror generates a cross-track scan line every 8 seconds. The spatial resolution at nadir is 40.5 km.

HSB

The HSB microwave multichannel radiometer has 4 channels. One channel measures radiation at 150 GHz and the other three are centered on 183.31 GHz.

All channels are used for atmospheric water vapor sounding. The rotating scanning mirror generates a cross-track scan line every 2.667 seconds. The spatial resolution at nadir is 13.5 km.

HSB ceased operation on February 5, 2003. We are continuing investigation with the hope of recovering the instrument at some future date. The impact on AIRS core products (temperature profile, water vapor profile, ozone burden) is negligible. Some future research products (cloud liquid water and precipitation) are adversely effected.

Relation of Fields of View of AIRS/AMSU/HSB

A granule of data contains 45 scansets, corresponding to 45 cross-track scans of the AMSU-A mirror. The AMSU-A radiance data sampled in a scanset are combined to create integrated radiances for 30 contiguous AMSU-A FOVs. An integration encompasses the time required for the mirror to sweep through an AMSU-A instantaneous FOV. Figure 1 illustrates the retrieval FOV pattern over Southern California that make up Granule 209 of AIRS/AMSU/HSB products on September 6, 2002.

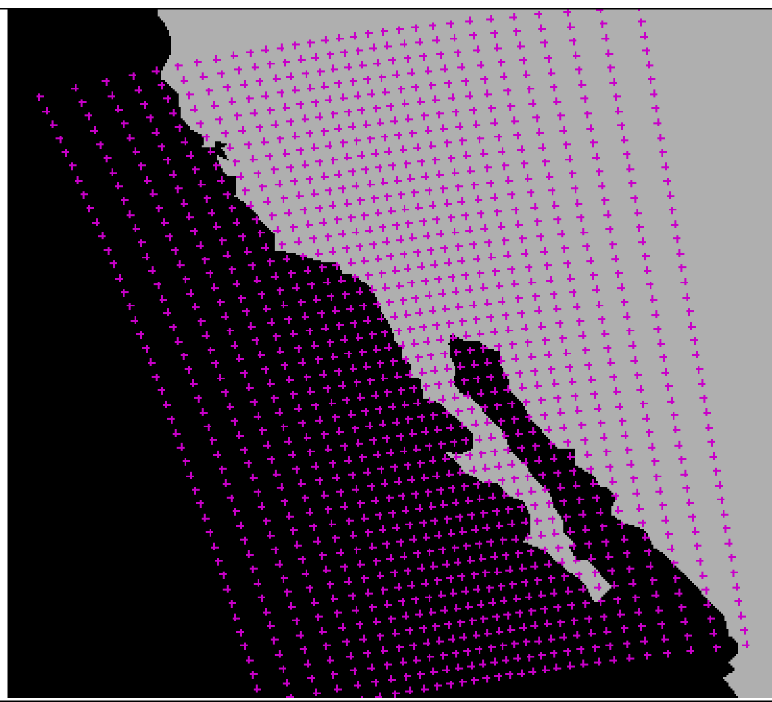

Figure 1: AIRS/AMSU/HSB Footprint Pattern
Sept 6, 2002; Granule 209

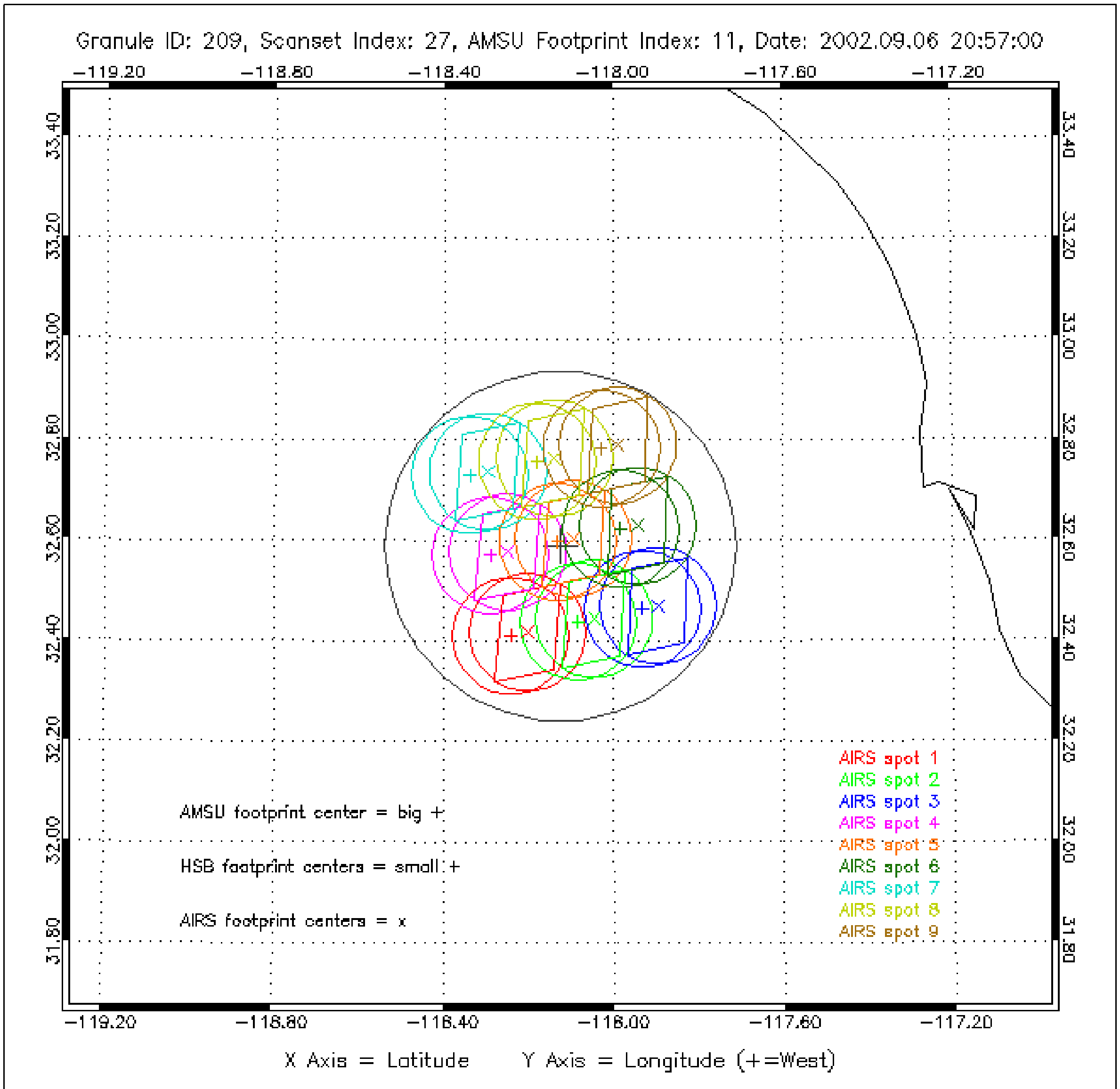

Figure 2: AIRS/AMSU/HSB Footprint Pattern
Sept 6, 2002; Granule 209; Scanset 27; Footprint 11
central (lat,lon) = (32.6°, -118.1°)

An AMSU-A FOV encompasses 9 AIRS FOVs (arranged in a 3x3 matrix) and 9 HSB FOVs (arranged in a 3x3 matrix). Each AIRS footprint encompasses 72 Vis/NIR pixels (arranged in a 9x8 rectangular array). This arrangement is illustrated in Figure 2, which was produced from the geolocation information contained within Granule 209 of data taken September 6, 2002, just off the coast of Southern California. The association shown comprises those data which are combined into a retrieval field-of-view located in the 11th AMSU-A FOV of the 27th AMSU-A scanset. The large circle represents the 3.3 deg instantaneous FOV of an AMSU-A observation. The smaller colored circles represent the 1.1 deg instantaneous FOVs of the associated arrays of AIRS and HSB observations. The colored rectangles represent the areas covered by the associated arrays of VIS/NIR pixels.

Since granule 209 is an ascending (daytime) granule, the spacecraft track tends toward the northwest. The scan direction as seen by an observer sitting on the spacecraft and facing the direction of motion is left to right. Thus the scan direction on the Earth for this granule is also left to right in this figure.

Within each scanset are three scanlines, corresponding to 3 cross-track scans of the AIRS and HSB mirrors. The AIRS and HSB radiance data sampled in each scanline are combined to create integrated radiances for 90 AIRS and 90 HSB footprints.

The VIS/NIR instrument has an array of 9 detectors arranged along the spacecraft track direction that look at the AIRS mirror. Sampling and integration are arranged so that there are 8 cross-track samples of each VIS/NIR detector as the mirror sweeps through one AIRS instantaneous FOV.

AIRS Science Processing System

System Overview

The AIRS Science Processing System (SPS) is a collection of programs, or Product Generation Executives (PGEs), used to process AIRS Science Data. These PGEs process raw, low level AIRS Infrared (AIRS), AIRS Visible (VIS), AMSU, and HSB instrument data to obtain temperature and humidity profiles.

AIRS PGEs can be grouped into three distinct processing phases for processing: Level 1A, Level 1B and Level 2. Each consecutive processing phase yields a higher-level data product. Levels 1A and 1B result in calibrated, geolocated radiance products. Level 2 processing derives temperature and humidity profiles, and cloud and surface properties. In addition to the standard processing PGEs, there are additional Browse PGEs that are run to produce an aggregate qualitative summary for each standard product and a radiosonde matchup PGE which collects and associates all AIRS products derived within 100 km and 3 hr of ADP operational upper air radiosonde launches reported in the National Centers for Environmental Prediction (NCEP) quality controlled final observation data files (PREPQC). Figure 3 is a diagram illustrating the processing flow of the AIRS Science Processing System.

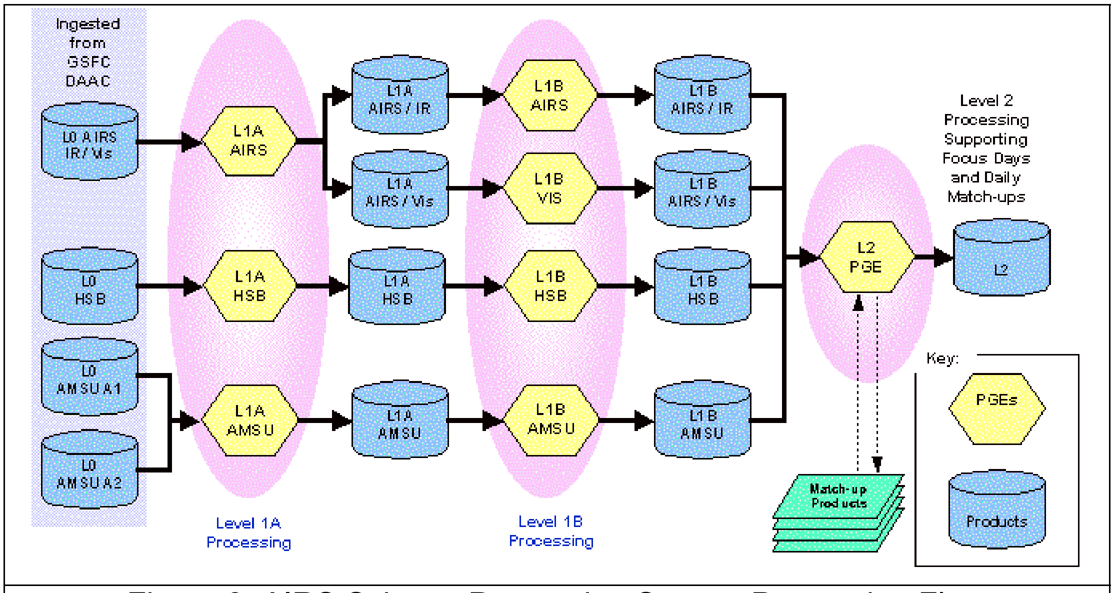

Figure 3: AIRS Science Processing System Processing Flow

Data Processing –Version 3.0

The V3.0 Release Science Processing Software (SPS) provided to the Goddard Space Flight Center (GSFC) Distributed Active Archive Center (DAAC) for L2 Product Generation is version 3.0.8.0 and represents the best refinement of all Level 1A, Level 1B and Level 2 PGEs as of July 18, 2003. It contains working versions of all Level 1A, Level 1B and Level 2 software modules. Specific features and characteristics of version 3.0.8.0 are described in other sections of this documentation.

The enhancements to Level 1A and Level 1B reflect lessons learned from analysis of post-launch data. The software is still under development, and JPL plans to continue to upgrade PGEs and will deliver updated code modules to the GSFC DAAC to support public release of Level 2 products during the middle of 2003 at approximately Launch + 13 months.

Level-1A Processing

AIRS data processing begins with receipt of Level 0 data from the Earth Observing System (EOS) Data and Operations System (EDOS). When Level 0 data are received, Level 1A PGEs are scheduled. The Level 1A PGEs perform basic house keeping tasks such as ensuring that all the Level 0 data are present and ordering the data into time of observation synchronization. Once the Level 0 data are organized, algorithms perform geolocation refinement and conversion of raw Data Numbers to Engineering Units (DN to EU). Finally, the level 1A data are collected into granules of data (six minutes of instrument data) and are forwarded to Level 1B PGEs for further processing.

Level-1B Processing

Level 1B PGEs receive 240 granules of AIRS (AIRS IR, AIRS VIS, AMSU and HSB) Level 1A EU data and produce calibrated, geolocated radiance products. Calibration data and calibration control parameters are analyzed to develop processing specifications for Level 1B processing. Then, the Level 1A data are processed, yielding our Level 1B standard products. Each type of AIRS Level 1A data is processed by a specialized Level 1B PGE. Each Level 1B PGE generates 240 granules of Level 1B standard products.

Level 1B PGEs produce 240 granules of 4 Level 1B standard products and 2 quality assessment (QA) subset products. Each granule is composed of 45 scansets. The Earth Science Data Type (ESDT) short names and normal granule sizes are:

Data Set	Short Name	Granule Size
L1B AMSU-A brightness temperatures	AIRABRAD	0.4 MB
L1B HSB brightness temperatures	AIRHBRAD	1.6 MB
L1B AIRS radiances	AIRIBRAD	122.1 MB
L1B VIS radiances	AIRVBRAD	21.0 MB
L1B AIRS QA	AIRIBQAP	6.5 MB
L1B VIS QA	AIRVBQAP	0.9 MB

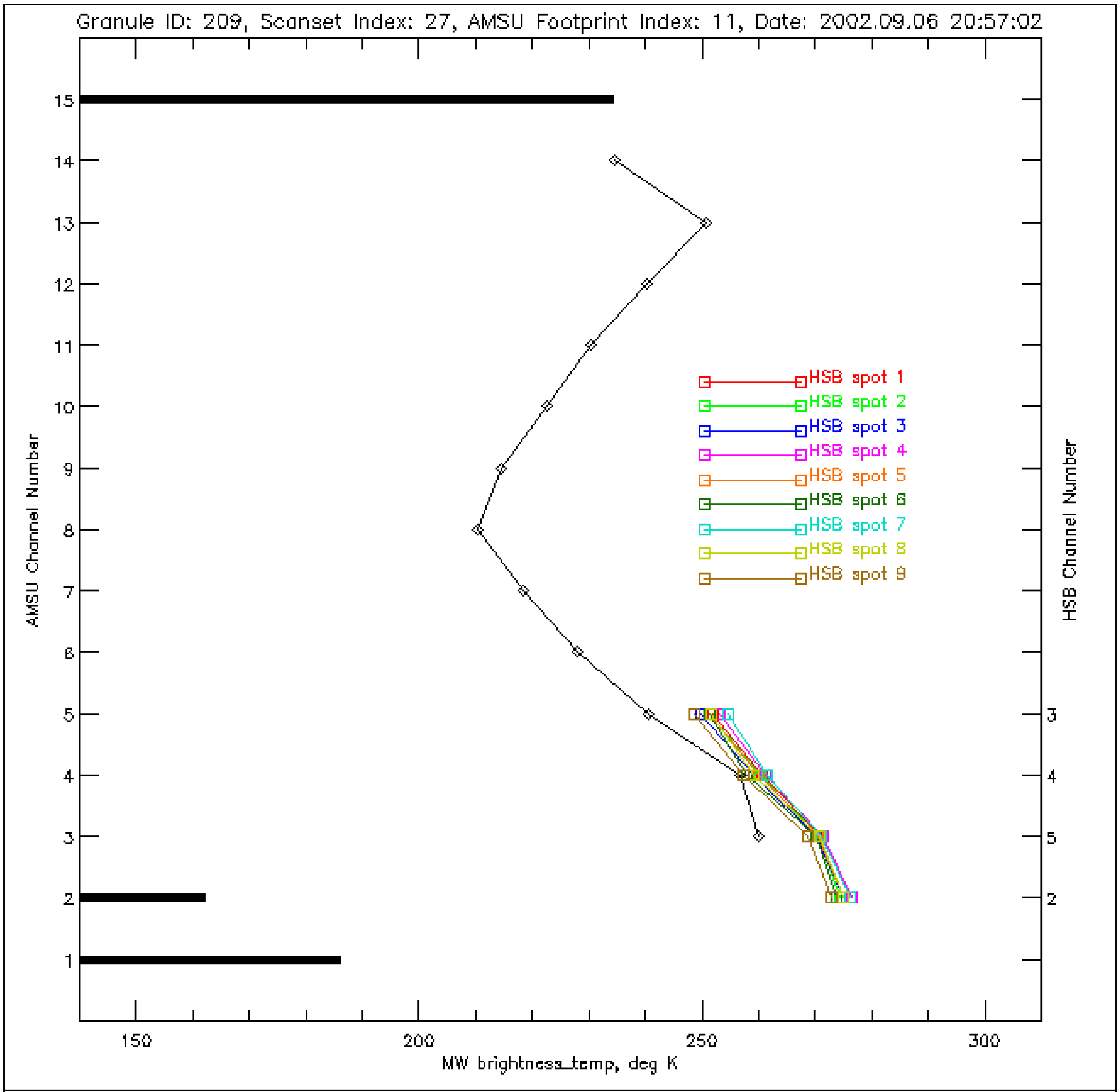

Figure 4: Level 1B Microwave Radiances (AMSU-A and HSB)
Sept 6, 2002; Granule 209; Scanset 27; Footprint 11

Figure 4 shows the combined AMSU and HSB spectra for the example AMSU FOV first introduced in Figure 2. Channel number is shown along the vertical axes (AMSU to the left and HSB to the right), and the horizontal axis represents brightness temperature. The AMSU temperature sounding channels (3-14) are connected with line segments and that plot can be viewed as a rudimentary representation of the temperature profile. The lowest channel is affected by the surface, however, which depresses the brightness temperature relative to the atmospheric temperature for this oceanic FOV. The nominal weighting functions for the tropospheric channels peak as follows: surface (#3), 1000 mb (#4), 750 mb (#4), 400 mb (#6), 250 mb (#7), 150 mb (#8)

AMSU channels 1, 2 and 15 are plotted separately as bars, since they are window channels that are primarily influenced by the surface brightness (i.e. the product of surface temperature and emissivity). Ocean emissivity is very low for channels 1 and 2, which causes very low brightness temperatures, even though the SST is relatively high. Channel 1 is warmer than channel 2 because it is affected by water vapor and clouds, which elevates the brightness temperature over the "cold" ocean background. Channel 15 is warmer still, due to a higher emissivity as well as higher sensitivity to both water vapor and clouds.

HSB has 4 channels and 9 FOVs within the single AMSU FOV, resulting in the 9 line plots shown to the right. The vertical order of the channels reflect the order of the peak in the weighting function rather than the serial channel number. These channels essentially reflect the atmospheric temperature near the peaks of the water vapor/liquid weighting functions. The lowest channel (#2) peaks near the surface (but is slightly "cooler" than the surface due to the emissivity). The highest channel (#3), which is too opaque to have much influence from the surface, has a brightness temperature somewhere between AMSU channels 4 and 5, which suggests it peaks at perhaps 850 mb. The spread between the 9 plots suggests there is some (but not much) variability in water vapor and liquid water.

Figure 5 shows the infrared Level 1B radiance spectra (AIRS) from the example FOV, which contains 9 AIRS spots. These data are contained in the L1B AIRS Radiance Product.

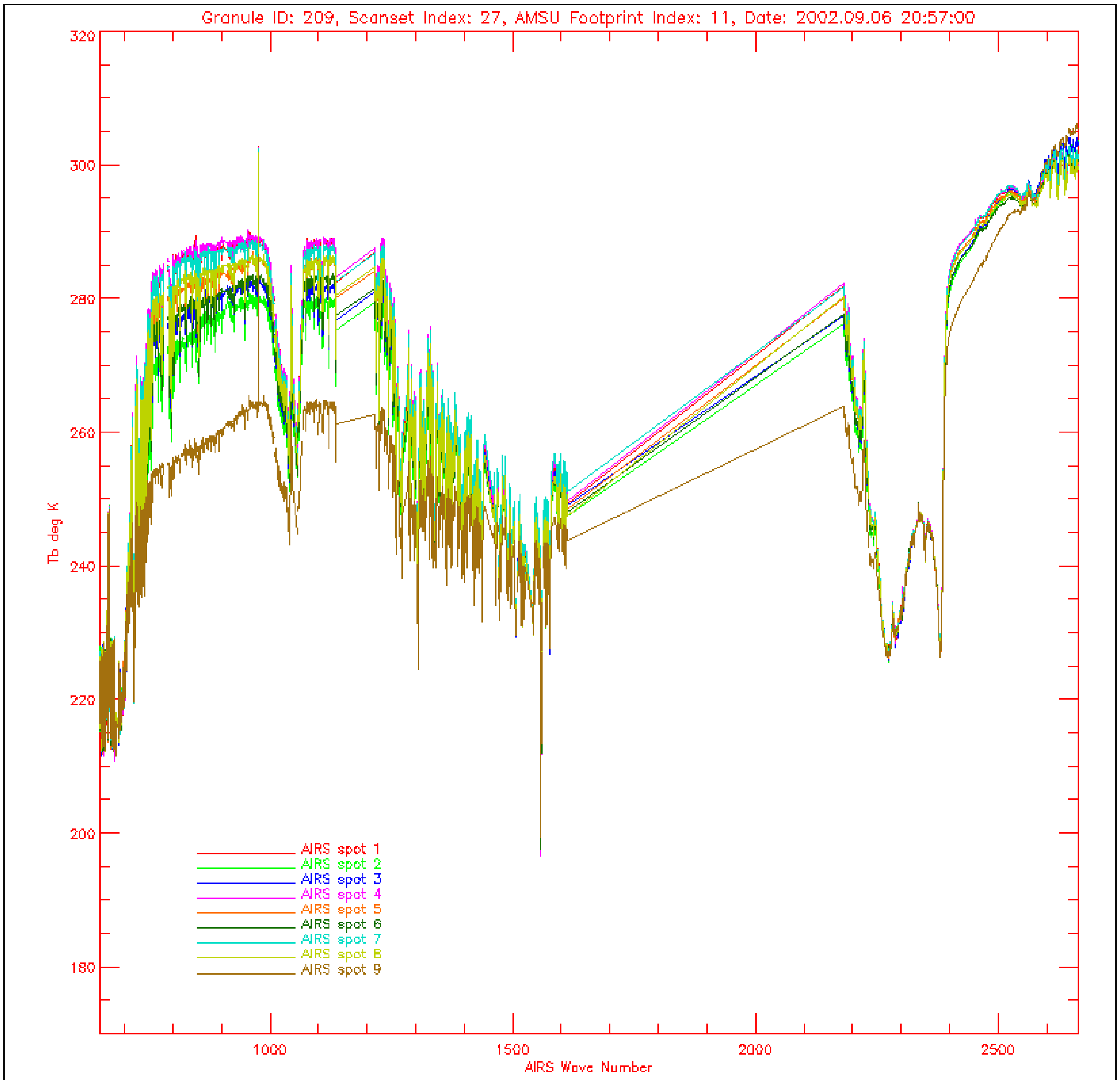

Figure 5: Level 1B Infrared Radiance Spectra (AIRS)
Sept 6, 2002; Granule 209; Scanset 27; Footprint 11

The brightness temperature in the 900 cm^{-1} region varies from around 260K to just under 290K. The AMSU footprint is over ocean and relatively uniform with the exception of cloud properties. Thus the variability of brightness temperature is mostly due to the effect of clouds. Cloud-clearing in the Level 2 retrieval estimates the clear column radiance from the cloud radiances by extrapolation. Note the slope of the coldest spectrum (color-coded brown) in the 900 cm^{-1} region. Since cloud tops tend to be colder than the surface, this is most likely the cloudiest of the nine AIRS footprints. The slope is one of the signatures of cirrus clouds. This spectrum appears to reflect more solar radiance than other AIRS spectra (i.e., higher brightness temperature in 2600 cm^{-1} region).

The AIRS Calibration Team documents the required inputs and outputs of the AIRS IR and VIS/NIR Level 1B processing software, algorithms for converting AIRS IR digital values to calibrated radiances, and QA algorithms and indicators in "**Atmospheric Infrared Sounder (AIRS) Level 1B Visible, Infrared and Telemetry Algorithms and Quality Assessment (QA) Processing Requirements**." Version 2.2 of this document, dated 2/14/03, is available at the link:

L1B_req_v2.2.pdf

The interested user will find additional information on QA indicators for AIRS IR and VIS/NIR L1B products in this document.

Experience with on-orbit AIRS data prompted the AIRS Calibration Team to alter some AIRS L1B algorithms (e.g. **AutomaticQAFlag**, DC Restore, pop detection, Moon-in-view, offset, noise estimation and gain). A brief AIRS Design File Memo describing these changes, dated 2/4/03, is available at the link:

l1bqa_changes.pdf

An AIRS Design File Memo (ADF-579) provides the initial assessment of the on-orbit performance of the VIS/NIR system, dated 6/12/02. It is available at the link:

VisInitialCheckout_pdf

Another AIRS Design File Memo (ADF-590-REVISED) dated 9/27/02 provides the results of the first accurate determination of instrument gains of the VIS/NIR detectors on-orbit via vicarious calibration in conjunction with the MISR-Terra Calibration Team operations at Railroad Valley Playa, Nevada. It is available at the link:

VisGainCalibration.pdf

The visible/near infrared data provide diagnostic support to the infrared retrievals as well as several research products. The field of radiances from the four channels can be combined to produce a low-resolution false color image of a granule. Figure 6 is an example, showing the entire granule from which the data of Figures 4 and 5 were taken.

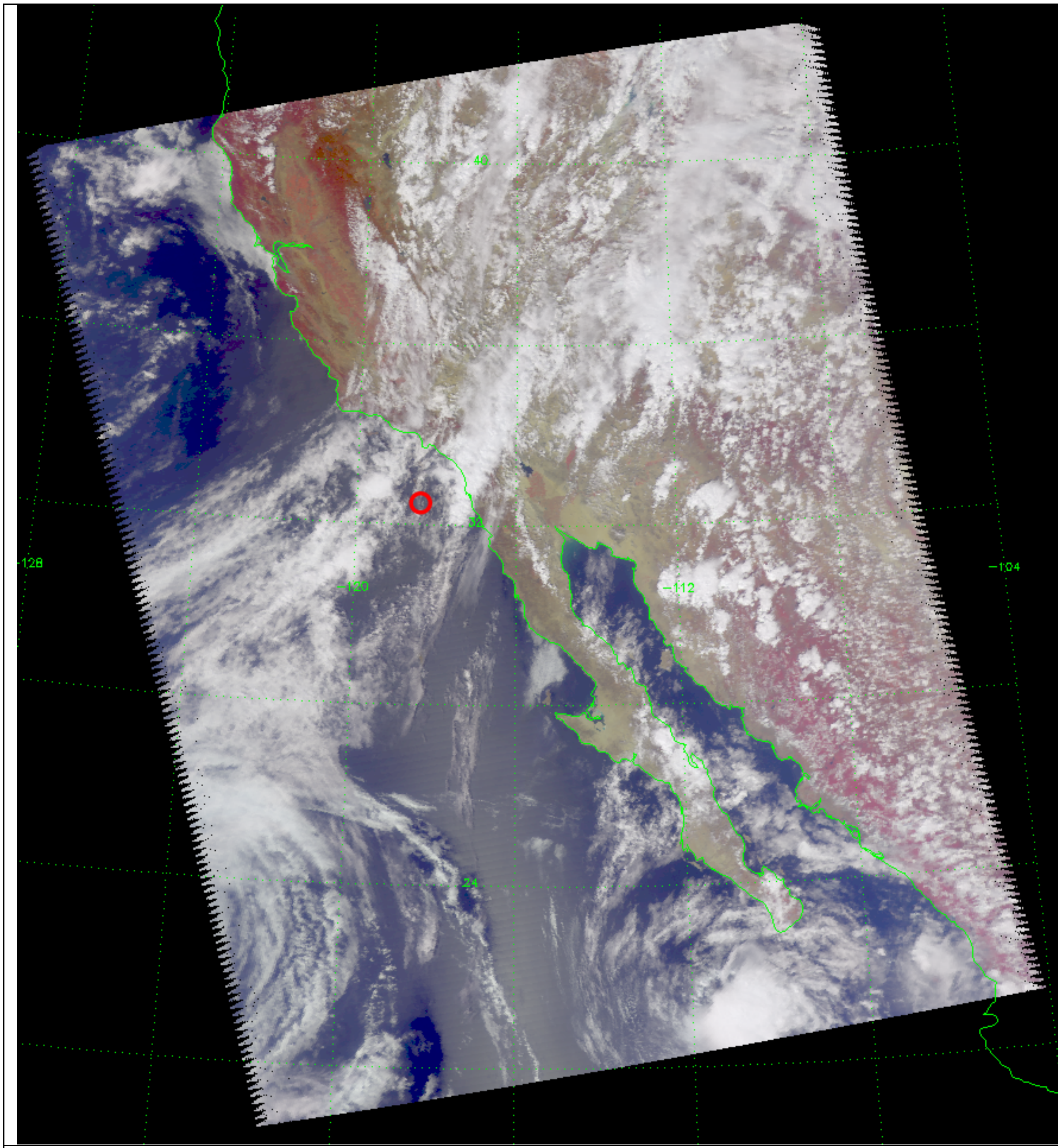

Figure 6: false color image of Sept 6, 2002 Granule 209
constructed from Vis/NIR radiances
red circle outlines example FOV; interior is approximate size of FOV

Level-2 Processing

The single Level 2 PGE reads corresponding Level 1B data granules from all instruments (AIRS IR, AIRS VIS, AMSU and HSB), the surface pressure at sea level from the NCEP forecast and a digital elevation map. Figure 7 is a schematic of the Level 2 algorithm flow. Depending upon tests applied in the main algorithm chain (the central chain in the diagram), the Level 2 product may be that reported from the "Final Retrieval" stage, the "Initial Regression" stage or the "MW-Only Retrieval" stage. Bits in RetQAFlag identify at which stage the ultimate product originates.

Level 2 produces 240 granules of each of the following AIRS products:

Data Set	Short Name	Granule Size
L2 Cloud-cleared radiances	AIRI2CCF	25.9 MB
L2 Standard Product	AIRX2RET	4.8 MB
L2 Support Product	AIRX2SUP	17.9 MB

as well as daily global browse maps of selected products which are a selection aid for ordering data from the GSFC DAAC. Each granule contains the data fields from 1350 retrievals laid out in an array of dimension 30x45, corresponding to the 30 AMSU footprints (cross-track) in each of 45 scansets (along-track).

Please note that the clear FOV detection algorithms are currently under development. There are several different clear detection algorithms being refined. They employ different algorithms depending upon their spatial resolution and spectral regime. Definitions of many of the clear flags and the thresholds that control them may be found in the link:

Clear_Flags.pdf

These clear flags are not yet incorporated into the algorithms contained in the Level 2 Processing stage. **The user is advised to ignore them**, for they and the discriminants that control them are still under development. They are described in the referenced document only because the user will encounter them in the products and may be tempted to use them to filter data. The user must not attempt to use these clear flags and discriminants.

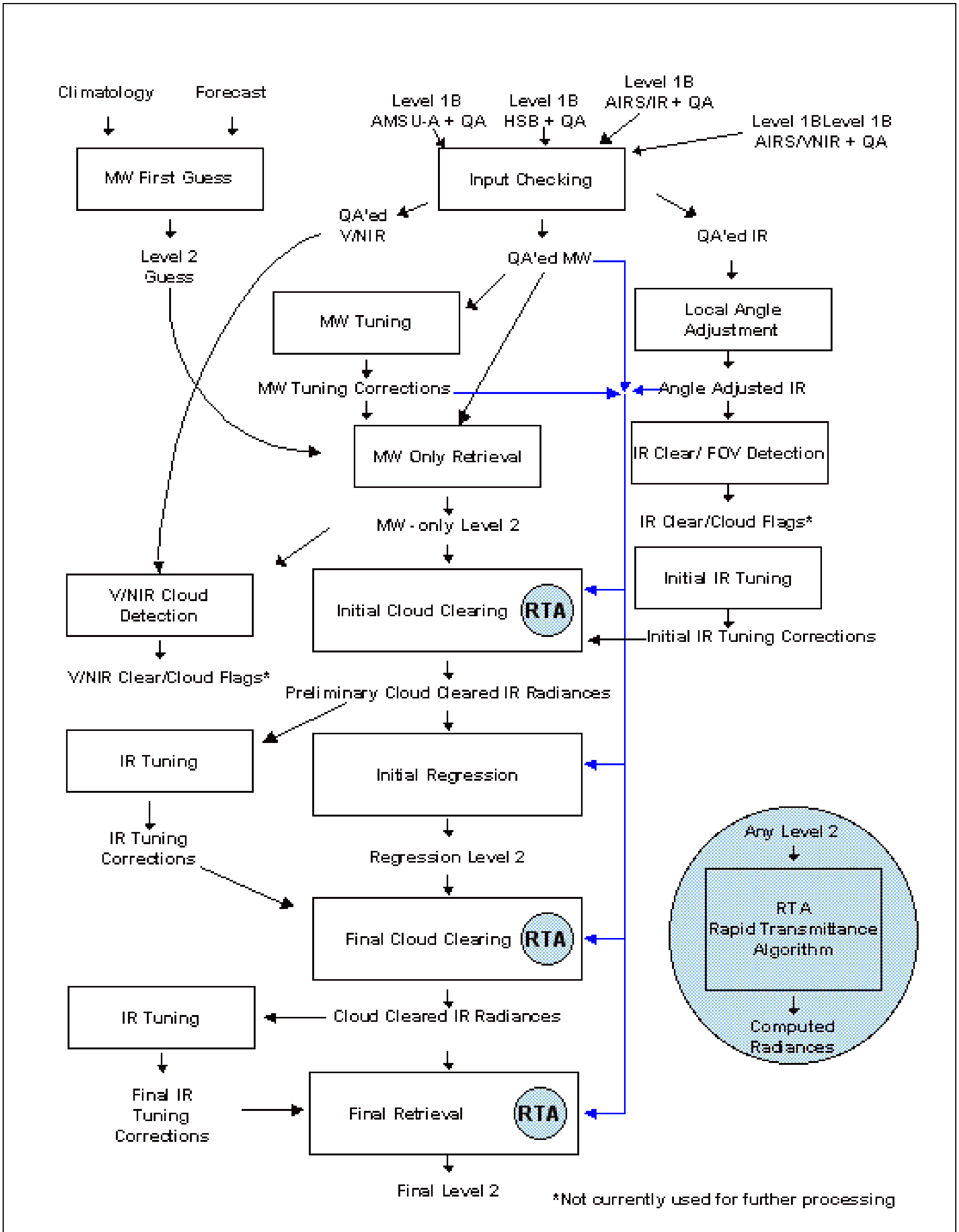

Figure 7: AIRS Level 2 Algorithm Flow

L2 Cloud-Cleared Radiance Product

See pp 67 - 71 of V3.0_Release_ProcFileDesc.pdf for a complete description. Please note that values of –9999 (if integer) and –9999.0 (if floating) denote invalid data.

The geolocation data fields of immediate interest to the user are:

- **Latitude** FOV boresight geodetic latitude (degrees North, -90->+90), dimension (30,45)
-
- **Longitude** FOV boresight geodetic longitude (degrees East, -180->+180), dimension (30,45)
-

The attribute of immediate interest to the user are:

- **freq** frequencies associated with each channel (cm^{-1}), dimension (2378)

This is a set of channel frequencies dynamically determined by the Level 1B software. Users are advised to use the fixed channel frequencies in the relevant channel properties file (see page 32 of this document) instead of these.

The swath data fields of immediate interest to user are:

- **RetQAFlag** always check this, see V3.0_Release_ProcFileDesc.pdf, dimension (30,45)
- **radiances** calibrated, geolocated channel-by-channel AIRS infrared spectra that would have been observed within each AMSU footprint if there were no clouds in the FOV (milliWatts/m^2/cm^{-1}/steradian), dimension (2378,30,45)
- **radiance_err** estimate of the radiance error, channel-by-channel (milliWatts/m^2/cm^{-1}/steradian), dimension (2378,30,45)
- **solzen** solar zenith angle (degrees, 0->180; daytime if < 85), dimension (30,45)
- **clear_flag** do not use; still under development and not yet validated, dimension (30,45)

Where the combined microwave/infrared retrieval is complete (bits 0, 1, 2, 3 and 4 of RetQAFlag are <u>all</u> <u>not</u> <u>set</u>), the **radiances** data field contains the final product calibrated, geolocated AIRS infrared spectra.

Where the combined retrieval is not complete (one or more of RetQAFlag bits 0, 1, 2, 3 and 4 are set), the **radiances** data field contains the last AIRS spectrum computed by the retrieval algorithm. This is an aid to the developers of the algorithm, providing insight into the stage of the retrieval that rejected the FOV. **Users should ignore radiances from incomplete retrievals.**

Figure 8 shows the AIRS Level 2 cloud-cleared radiance spectrum (**radiances**) from the example FOV converted to brightness temperature. These data contained in the L2 Cloud-Cleared Radiance Product.

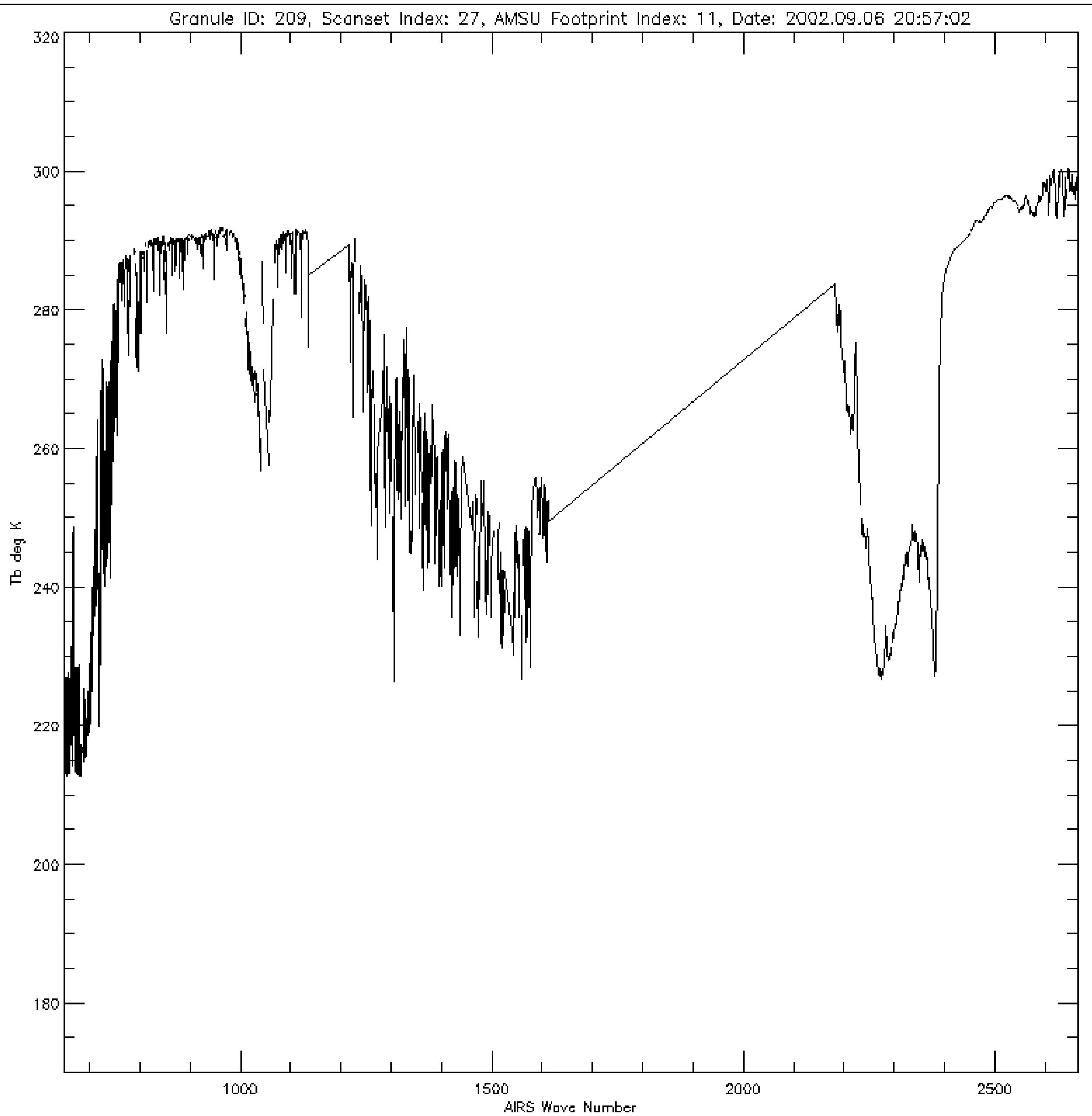

Figure 8: Level 2 Cloud-Cleared Infrared Radiance Spectrum (AIRS)
Sept 6, 2002; Granule 209; Scanset 27; Footprint 11

Figure 9 illustrates the magnitude of the difference between the final Level 2 cloud-cleared radiance spectrum reported for the example FOV and the nine observed L1B AIRS radiance spectra. The bulk of this difference is due to the effect of clouds, which is removed during the Level 2 processing. The cloudiest AIRS footprint was spot #9 (color-coded in Figures 2,4,5 and 8 by brown). The least cloudy was spot #4 (color-coded in Figures 2,4,5 and 8 by magenta).

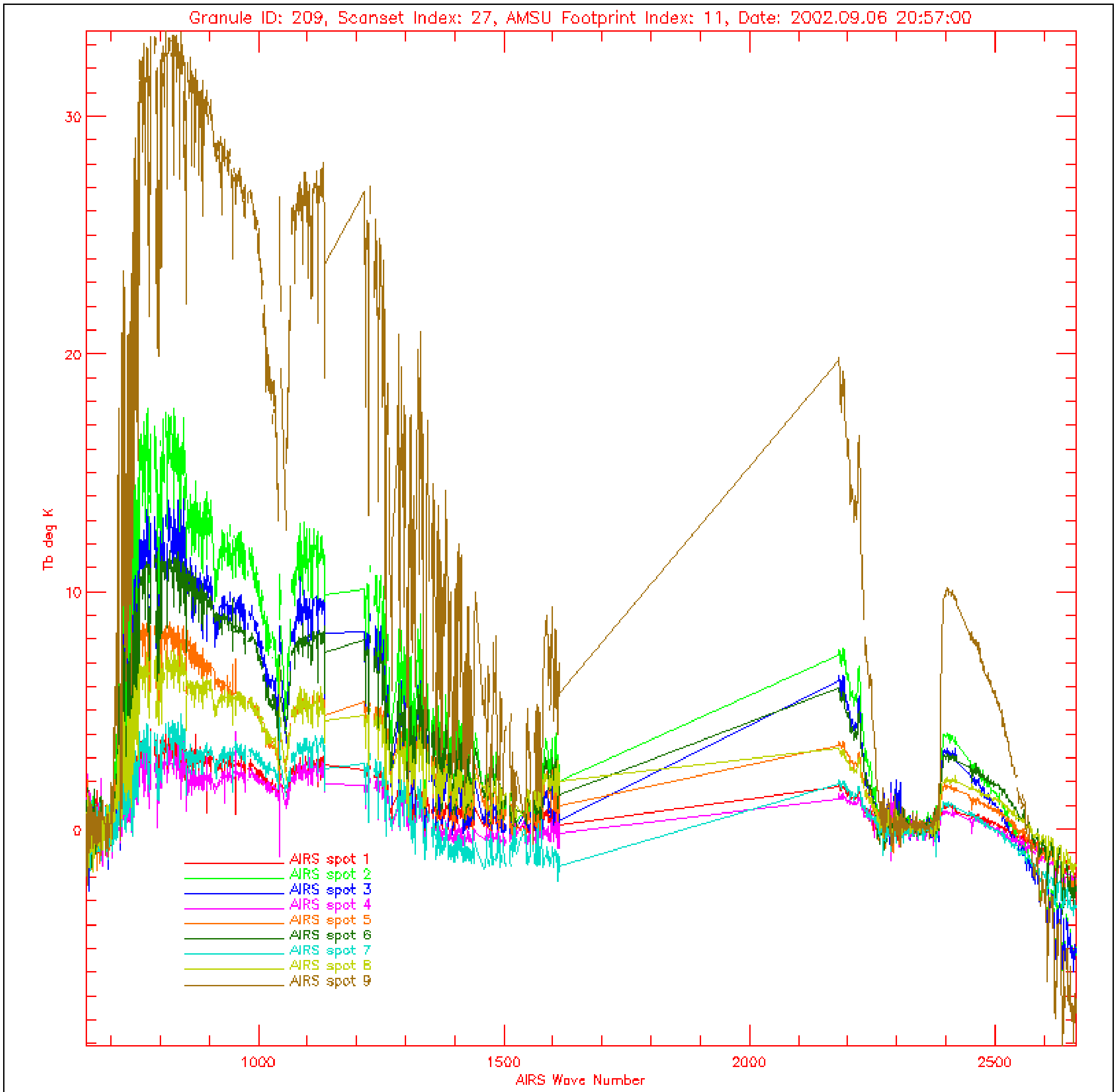

Figure 9: (L2 Cloud-Cleared Spectrum – L1B Observed Spectra)
Sept 6, 2002; Granule 209; Scanset 27; Footprint 11

L2 Standard Product

See pp 59 - 65 of V3.0_Release_ProcFileDesc.pdf for a complete description. Please note that values of –9999 (if integer) and –9999.0 (if floating) denote invalid data.

Please read the document that discusses the finer points of AIRS products defined on levels, layers, TOA and surface.

AIRS_L2_levels_and_layers.pdf

The geolocation data fields of immediate interest to the user are:

- **Latitude** FOV boresight geodetic latitude (degrees North, -90->+90), dimension (30,45)
- **Longitude** FOV boresight geodetic longitude (degrees East, -180->+180), dimension (30,45)

The attribute of immediate interest to the user are:

- **pressStd** standard pressure (mb) for each of 28 levels in atmosphere associated with temperature, moisture and ozone profiles. The array order is from the surface upward, in conformance with WMO standard. Note that topography may place some of these levels below the surface, dimension (28)

The swath data fields of immediate interest to the user are:

- **RetQAFlag** always check this, see V3.0_Release_ProcFileDesc.pdf dimension (30,45)
- **PsurfStd** surface pressure, interpolated from forecast and mean topography of FOV (mb), dimension (30,45)
- **nSurfStd** index of last physically meaningful profile entries. Retrieved profile entries beyond this index are filled with –9999. It may be level just above or just below the surface, dimension (30,45)
- **TSurfStd** retrieved surface skin temperature (K), dimension (30,45)
- **TSurfAir** retrieved surface air temperature (K), dimension (30,45)
- **totH2Ostd** total precipitable water vapor in air column (kg/m^2), dimension (30,45)
- **totO3Std** total ozone burden in air column (Dobson Units), dimension (30,45)
- **TAirStd** retrieved atmospheric temperature profile (K) at the pressStd pressures. Array values below the surface (index < nSurfStd) may not

always be filled with –9999.0. Always check nSurfStd to avoid invalid TAirStd elements below the surface, dimension (28,30,45)

- **H2OMMRStd** retrieved water vapor mass mixing ratio (gm/kg_dry_air). Array values below the surface (index < nSurfStd) may not always be filled with –9999.0. Always check nSurfStd to avoid invalid H2OMMRStd elements below the surface, dimension (28,30,45)
- **H2OMMRSat** retrieved water vapor saturation mass mixing ratio (gm/kg_dry_air). Array values below the surface (index < nSurfStd) may not always be filled with –9999.0. Always check nSurfStd to avoid invalid H2OMMRSat elements below the surface, dimension (28,30,45)
- **O3VMRStd** retrieved ozone volume mixing ratio (ppm). Array values below the surface (index < nSurfStd) may not always be filled with –9999.0. Always check nSurfStd to avoid invalid O3VMRStd elements below the surface, dimension (28,30,45)
- **numHingeSurf** number of IR hinge points for retrieved surface emissivity and reflectivity. It can be as large as 100. Usually 7, 49 or 51 depending upon the retrieval outcome. A MW-only retrieval results in 7. A full MW/IR retrieval results in 49. A partial MW/IR retrieval results in 51. dimension (30,45)
- **freqEmis** Frequencies (cm^{-1}) for retrieved surface emissivity and reflectivity in order of increasing emissivity. Only the first numHingeSurf are valid, dimension (100,30,45)
- **emisIRStd** The retrieved spectral IR surface emissivity in order of increasing frequency. Only the first numHingeSurf are valid, dimension (100,30,45)
- **rhoIRStd** The retrieved spectral IR bi-directional surface reflectivity in order of increasing frequency. Only the first numHingeSurf are valid, dimension (100,30,45)
- **NumCloud** number of retrieved cloud layers (= 0, 1 or 2), dimension (30,45)
- **TcldTopStd** retrieved cloud top temperature (K) for each of up to two retrieved cloud layers, uppermost layer first. Use with caution, under development, dimension (2,30,45)
- **PcldTopStd** retrieved cloud top pressure (mb) for each of up to two retrieved cloud layers, uppermost layer first. Use with caution, under development, dimension (2,30,45)
- **CldFrcStd** retrieved cloud fraction (0->1) for each AIRS footprint associated with the retrieval FOV, for each layer. Ignore CldFrcStd values exactly equal to zero. The current cloud clearing code sometimes yields a false zero result. Values very near zero, i.e., 0.0001 or greater, are correct. Use with caution, under development, dimension (2,3,3,30,45)
- **clear_flag_4um** a flag indicating clear FOV valid over ocean only at night, which is based on the agreement of the predicted SST using observed AIRS radiance at 2616 cm^{-1} and 2707 cm^{-1} and the coherency

among the 9 AIRS spots in the FOV at 2616 cm^{-1},. A value of 1 indicates possibly clear. Ignore, under development, dimension (3,3,30,45)

- **clear_flag_11um** a flag indicating clear FOV valid over ocean day and night, which is based on the agreement of the predicted SST using AIRS 11 um split window test and the coherency among the 9 AIRS spots in the FOV. A value of 1 indicates possibly clear. Ignore, under development, dimension (3,3,30,45)
- **clear_flag** a flag indicating clear FOV derived in the final retrieval step. Ignore, under development, dimension (30,45).

Figure 10 illustrates representative physical retrieval data fields from the example FOV. These data are contained in the L2 Standard Product. The upper panels (left to right) are respectively **TAirStd**, **H2OMMRStd**, **O3VMRStd**, and **emisIRStd**. The temperature, moisture and ozone plots also show the estimated errors as error bars on the points. The temperature plot also includes **TcldTopStd** and **TsurfStd** and their errors. AIRS radiances are relatively insensitive to water vapor in the stratosphere. The current retrieval algorithm reports a climatological water vapor profile above the tropopause. A dry layer near 100 mb is occasionally seen, as in the **H2OMMRStd** panel, and is an artifact of combining a retrieval in the troposphere with a climatological water vapor profile in the stratosphere.

The lower panels give **PcldTopStd** and T**cldTopStd** and graphical representations of **CldFrcStd** and **CldFrcStderr**. A completely filled circle would indicate CldFrcStd = 1.0. The errors are indicated by the size of the arcs. A single cloud formation (at 429.6 mb) was retrieved, and AIRS spot #9 (color-coded brown) is indeed the cloudiest. AIRS spot #4 (color coded magenta) is the least cloudy.

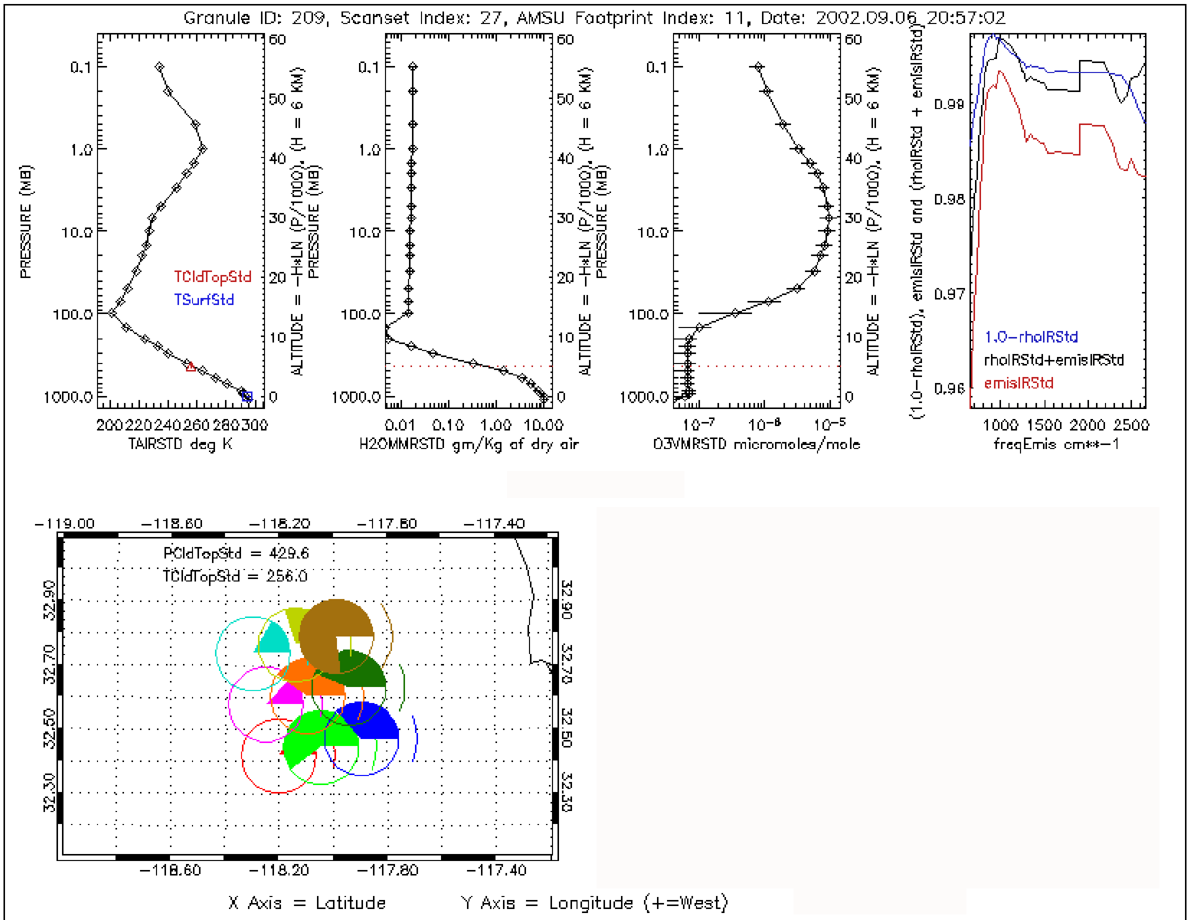

Figure 10: Data Fields from Level 2 Standard Product
Sept 6, 2002; Granule 209; Scanset 27; Footprint 11

L2 Support Product

See pp 73 - 87 of V3.0_Release_ProcFileDesc.pdf for a complete description. Please note that values of –9999 (if integer) and –9999.0 (if floating) denote invalid data. General users are urged to order the L2 Standard Product. The L2 Support Product is intended for the knowledgeable, experienced user of AIRS products. It contains high resolution profiles intended to be used for computation of radiances, as-yet unimplemented research products and various parameters and intermediate results used to evaluate and track the progress of the retrieval algorithm.

Please read the document that discusses the finer points of AIRS products defined on levels, layers, TOA and surface.

AIRS_L2_levels_and_layers.pdf

The geolocation data fields of immediate interest to the user are:

- **Latitude** FOV boresight geodetic latitude (degrees North, -90->+90), dimension (30,45)
- **Longitude** FOV boresight geodetic longitude (degrees East, -180->+180), dimension (30,45)

The attribute of immediate interest to the user are:

- **pressSupp** standard pressure (mb) for each of 100 levels in atmosphere associated with temperature, moisture and ozone profiles. The array order is from the top of atmosphere downward. This is the reverse of pressStd ordering. Note that topography may place some of these levels below the surface, dimension (100)

The swath data fields of immediate interest to the user are:

- **RetQAFlag** always check this, see V3.0_Release_ProcFileDesc.pdf dimension (30,45)
- **PsurfStd** surface pressure, interpolated from forecast and mean topography of FOV (mb), dimension (30,45)
- **nSurfSup** index of last physically meaningful profile entries. Retrieved profile entries beyond this index are filled with diagnostic values that may appear to be physically meaningful but are not. It may be level just above or just below the surface, dimension (30,45)
- **TSurfStd** retrieved surface skin temperature (K), dimension (30,45)
- **TSurfAir** retrieved surface air temperature (K), dimension (30,45)

- **TAirSup** retrieved atmospheric temperature profile (K) at the pressSupp pressures. Array values below the surface (index < nSurfStd) are not physically meaningful. In particular, the first level below the surface contains an extrapolated value. Always check nSurfSup to identify this extrapolated. The surface value (at PsurfStd) must be calculated by interpolating in the log(pressure) domain between this value and the value in the next level up (index = nSurfSup-1), dimension (100,30,45)
- **H2OCDSup** retrieved layer column water vapor (molecules/cm^{-2}). The layer corresponding to value H2OCDSup(index) is bounded by pressSupp(index) at the bottom and pressSupp(index-1) at the top. Array values below the surface (index < nSurfStd) are not physically meaningful. In particular, the first level below the surface contains an extrapolated value. Always check nSurfSup to identify this extrapolated. The surface value (at PsurfStd) must be calculated by interpolating in the log(pressure) domain between this value and the value in the next level up (index = nSurfSup-1), dimension (100,30,45)
- **lwCDSup** retrieved layer column cloud liquid water (molecules/cm^{-2}). The layer corresponding to value lwCDSup(index) is bounded by pressSupp(index) at the bottom and pressSupp(index-1) at the top. Array values below the surface (index < nSurfStd) are not physically meaningful. In particular, the first level below the surface contains an extrapolated value. Always check nSurfSup to identify this extrapolated. The surface value (at PsurfStd) must be calculated by interpolating in the log(pressure) domain between this value and the value in the next level up (index = nSurfSup-1). Missing if HSB instrument is not operational, dimension (100,30,45)
- **O3CDSup** retrieved layer column ozone (molecules/cm^{-2}). The layer corresponding to value O3CDSup(index) is bounded by pressSupp(index) at the bottom and pressSupp(index-1) at the top. Array values below the surface (index < nSurfStd) are not physically meaningful. In particular, the first level below the surface contains an extrapolated value. Always check nSurfSup to identify this extrapolated. The surface value (at PsurfStd) must be calculated by interpolating in the log(pressure) domain between this value and the value in the next level up (index = nSurfSup-1), dimension (100,30,45)

Browse Processing

As 240 granules of Level 1B and Level 2 data are produced for a day, a specialized set of products, termed Browse Products, are also produced each day for each Level 1B and Level 2 standard product. Each Browse Product is a simplification of data found within its associated standard product set. Summary Browse Products are high-level pictorial representations of AIRS Instrument (AIRS Infrared, AMSU-A and HSB) data binned in 1°x1° boxes, designed as an aid to ordering data from the GSFC DAAC or the EOS Data Gateway (EDG). By viewing AIRS Browse images, users will find it easier to select science granules that correspond to features of interest. Some users may also find Summary Browse images to be useful tools in their own right.

The AIRS Browse Products included in the data are:

Data Set	Short Name	Granule Size
L1B AMSU selected radiances browse	AIRABDBR	0.6 MB
L1B HSB radiance browse	AIRHBDBR	0.3 MB
L1B AIRS selected radiances browse	AIRIBDBR	0.4 MB
L2 Cloud-cleared selected radiances browse	AIRI2DBR	0.4 MB
L2 retrieval browse	AIRX2DBR	0.6 MB

L1B Summary Browse Products

L1B Summary Browse Products represent a twice-daily global snapshot of selected AIRS/AMSU/HSB observed radiances for selected data channels, one for ascending (daytime) nodes and one for descending (nighttime) nodes. This browse consists of the following observed radiance products averaged over an AMSU FOV:

<u>Observed AMSU-A Radiances</u>

- Channel 1 23.8 GHz, measures atmospheric temperature
- Channel 2 31.4 GHz, measures atmospheric temperature
- Channel 3 50.3 GHz, measures atmospheric temperature
- Channel 4 52.8 GHz, measures atmospheric temperature
- Channel 5 53.596 ± 1.15 GHz, measures atmospheric temperature
- Channel 6 54.4 GHz, measures atmospheric temperature
- Channel 7 54.94 GHz, measures atmospheric temperature
- Channel 15 89.0 GHz, measures water vapor

Observed HSB Radiances
- Channel 2 150.0 GHz, measures water vapor
- Channel 3 183.31 ± 1.0 GHz, measures water vapor
- Channel 4 183.31 ± 3.0 GHz, measures water vapor
- Channel 5 183.31 ± 7.0 GHz, measures water vapor

Observed AIRS Radiances
- channel 709.74 cm^{-1}, nadir weighting function peaks at 200mb
- channel 1040.14 cm^{-1}, representative of O_3 channel
- channel 1109.49 cm^{-1}, representative window channel
- channel 1304.23 cm^{-1}, representative CH_4 channel
- channel 1310.06 cm^{-1}, representative H_2O channel

L2 Summary Browse Products

L2 Summary Browse Products represent a twice-daily global snapshot of selected retrieval products thought to be most helpful to the user for deciding which data to order. This browse consists of the following retrieval products within an AMSU FOV:

Cloud-Cleared AIRS Radiances
- channel 709.74 cm^{-1}, nadir weighting function peaks at 200mb
- channel 1040.14 cm^{-1}, representative of O_3 channel
- channel 1109.49 cm^{-1}, representative window channel
- channel 1304.23 cm^{-1}, representative CH_4 channel
- channel 1310.06 cm^{-1}, representative H_2O channel

Physical Retrieval
- Percent Cloud Cover
- Skin Surface Temperature
- Total Water Vapor Burden
- Total Ozone Burden
- Microwave First Guess Liquid Water Burden
- Microwave Rain Rate
- Visible Percent Clear (daytime only)
- Visible Variability Index (daytime only)

The daily browse products will have gores between the satellite paths where there is no coverage for that day. Each summary browse product file consists of several unsigned 8-bit arrays. Each array is a 180 x 360 two-dimensional global map of the Earth's surface, at 1degree by 1degree resolution, using a rectilinear projection where each grid cell is bounded by latitude and longitude lines. The longitudinal extent is from -180.0 degrees to +180.0 degrees, with the prime meridian in the center of the image. Each array element has a value between 0 and 255 and is a re-scaled representation of a floating-point number (visible images are integer). The relationship between pixel value (pv) and input floating point data value (dv) is:

$$pv = \frac{255 \times (dv - \min(dv))}{(\max(dv) - \min(dv))} + 1$$

The files are in HDF RIS8 (8-bit raster) format and for each image within the file there is an associated color palette. Additionally, for each image there are descriptive annotations in HDF DFAN format. The annotations consist of image title, image description, and the minimum, mean, and maximum of the original data values and the corresponding pixel values. The minimum and maximum of the original data values may be used to annotate a color bar.

V3.0 Release of L2 Data Information

Data Disclaimer and Quick Start Quality Assurance

Data Disclaimer

The accompanying file:

Data_Disclaimer.pdf

provides information which affects the availability of data for ordering (i.e., may be unavailable due to instrument outage or spacecraft maneuvering). It also lists the known liens against each instrument.

Quick Start Quality Assurance

The accompanying file:

L1B_QA_Quick_Start.pdf

Is a guide to the most basic L1B AIRS/AMSU/HSB quality assurance (QA) parameters that a novice user of AIRS/AMSU/HSB data should access to judge its quality.

A brief user guide for the selected L1B AIRS Radiance Product QA swath data fields is available at the link:

Select_AIRS_QA_Fields.pdf

AIRS

AIRS IR channel characteristics

The properties of the 2378 AIRS instrument detectors are individually listed in self-documenting text files. Some properties of the channels change slowly with time or discontinuously whenever the instrument is warmed by a spacecraft safety shutdown or in a defrost cycle. Whenever this occurs, a recalibration exercise is performed and a new channel properties file is created. Thus a series of these files will result. The L1B PGE must use the proper one (chosen by date of properties file and date of data) for initial processing and reprocessing.

The file names contain a date, identifying the first date for which they are valid (and supersede a channel properties file containing an earlier date). As of this release, there are four such files covering the time period from 8/30/02 to the present. Text versions may be accessed through the following links:

Channel Properties Files
L2.chan_prop.2002.08.30.v6.6.2.pdf
L2.chan_prop.2002.09.17.v6.6.3.pdf
L2.chan_prop.2002.10.22.v6.6.4.pdf
L2.chan_prop.2003.01.10.v6.6.8.pdf

Instrument state

- Instrument is in nominal science mode (instrument flag **OpMode** = ‘Operate’)
- The quality of the calibration is judged to be good

Radiometric calibration

Refer to papers:

Pagano, T.S., Aumann, H.H., Hagan, D.E., and Overoye, K., “Prelaunch and In-Flight Radiometric calibration of the Atmospheric infrared Sounder (AIRS)”, ”, *IEEE Transactions on Geosciences and Remote Sensing*, pp 265-273, 41., 2003.

Hagan, D. and P. Minnett, “AIRS radiance validation over ocean from sea surface temperature measurements”, *IEEE Transactions on Geosciences and Remote Sensing*, pp 432-441, 41., 2003.

Spectral Calibration

Refer to paper:

Gaiser, S. L., H. H. Aumann, L. L. Strow, S. E. Hannon, and M. Weiler, ”In-flight spectral calibration of the atmospheric infrared sounder (AIRS)”, *IEEE Trans. Geosci. Remote Sensing*, vol. 41, pp. 287-297, Feb. 2003

Spatial Calibration

Refer to paper:

Gregorich, D. T. and H. H. Aumann, ”Verification of AIRS Boresight Accuracy Using Coastline Detection”, *IEEE Trans. Geosci. Remote Sensing*, vol. 41, pp. 298-302, Feb. 2003

VIS/NIR

Instrument state

- Nominal science mode

Radiometric calibration and Channel Characteristics

Refer to paper:

Gautier, C., Y. Shiren, L. L. and M. D. Hofstadter, ”AIRS vis/near IR instrument”, *IEEE Trans. Geosci. Remote Sensing*, vol. 41, pp. 330-342, Feb. 2003

The Vis/NIR L1B radiances have been calibrated and validated by vicarious calibration, as described in AIRS Design File memo ADF-590-Revised dated 9/27/02. It is available at the link:

VisGainCalibration.pdf

Field data collected at the time of this writing, but not yet published, confirms the radiances are valid to the quoted accuracy: 11% for Channel #1 and 7% for Channels #2,3 and 4. This accuracy does not apply to the first few samples of Channel #4 in each scanline. These data have anomalously low values as reported in the accompanying disclaimer file.

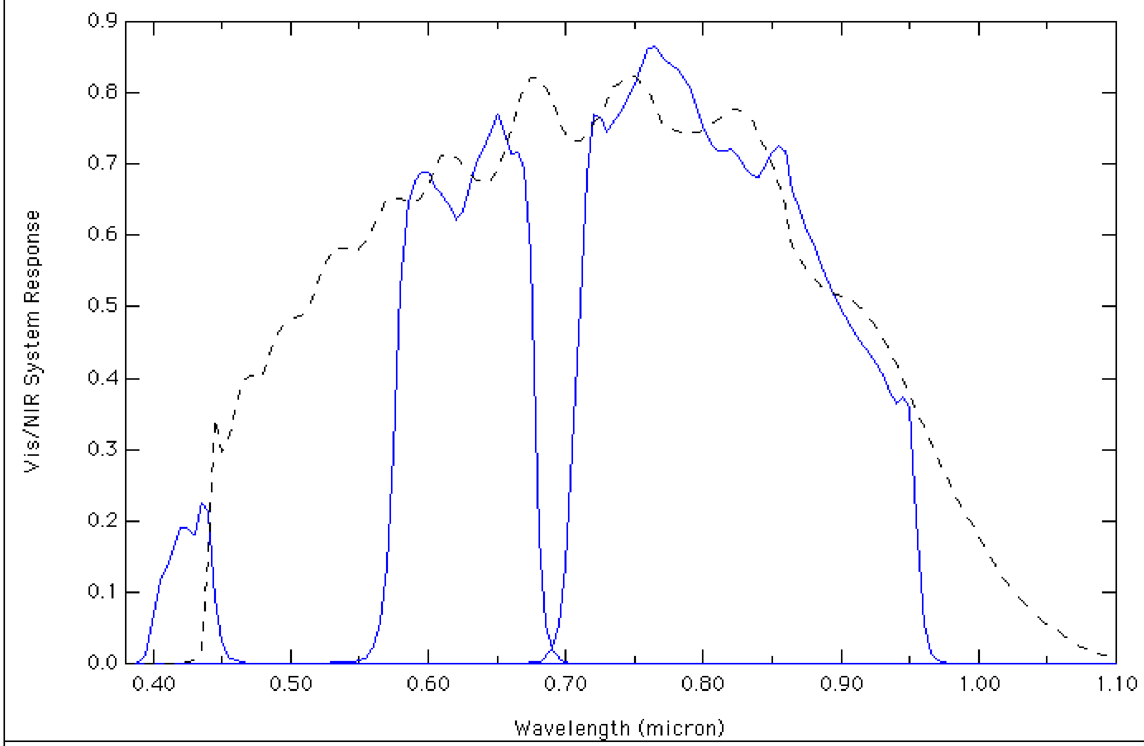

Figure 11: The approximate spectral response of the four VIS/NIR channels. The three solid curves are, from left to right, Channels 1, 2, and 3. The dashed curve is the response of Channel 4.

Channel 1 (0.40 to 0.44 µm) is designed to be most sensitive to aerosols. Channels 2 (0.58 to 0.68 µm) and 3 (0.71 to 0.92 µm) approximate the response of AVHRR channels 1 and 2, respectively, and are particularly useful for surface studies. (AVHRR is an imaging instrument currently carried by NOAA polar orbiting satellites.) Channel 4 has a broadband response (0.49 to 0.94 µm) for energy balance studies.

Pointing

- Validation of the Vis/NIR pointing is not yet complete, but initial comparisons to other satellite data (Terra MISR and Aqua MODIS instruments) suggests it is accurate to within 0.3 degrees (corresponding to 4 km at nadir).

  Note: To reduce the data volume, not every VIS/NIR pixel is geolocated. Instead, only the four “corner pixels” of the 9x8 grouping associated with each IR footprint are geolocated. (A bi-linear interpolation can be used to locate the remaining pixels.) In the data files, four-element arrays called “cornerlats” and “cornerlons” carry this information. The first array element is the upper-left pixel when viewing an image aligned with “up” being North. The second element is the upper-right pixel. The third and fourth elements refer to the lower-left and lower-right pixels, respectively.

AMSU-A

Instrument state

- Instrument is in nominal science mode
- Both AMSU modules are in the optimal space view position

Radiometric calibration

- The data have been reprocessed with the current best calibration algorithm and calibration parameters.
- Calibration accuracy is estimated to be on the order of 1 K
- Radiometric sensitivity is better than requirements – see AMSU-A channel characteristics table, below.
- The quality of the calibration is judged to be good, but at present there are substantial scan biases. Modeling of the sidelobe pickup is under way to correct these scan biases.
- L1B data contain fields named "**antenna_temp**" and "**brightness_temp**". Both are well calibrated and without sidelobe correction in this release. The **brightness_temp** data field will include sidelobe correction in a future release. In this release the two fields are identical.
- Channel 7 has additional correlated noise, and should be avoided in applications that use single measurements, such as comparisons with collocated soundings. It may be used in applications in which some averaging is done (i.e. gridding/binning or regional averages)
- Channel 6 exhibits additional correlated noise; similar to channel 7 but much smaller
- Channel 9 exhibits occasional popping, i.e. the calibration counts suddenly drop and then quickly recover. This typically occurs no more than once per orbit.
- Channel 14 may have correlated noise, but it is minor

Preliminary Pointing Analysis using Coastlines

- Valid for channels 1, 2, 3, 15 (window channels)
- Pitch error < 10% of FOV (< 4 km at nadir)
- Roll Error estimated to be less than 20% of FOV
- Yaw error estimated to be less than 30% of FOV at swath edge

Relevant analysis

- See Accompanying Document: **MW_L1B_Assessment.pdf** which is based upon a status report given to the AIRS Science Team in September 2002 and has been updated as of March 10, 2003.

AMSU-A channel characteristics

Ch #	Module	Center freq [MHz]	Stability [MHz]	Bandwidth [MHz]	On-Orbit NEdT[K]	T/V NEdT[K]	Pol
1	A2	23800	±10	1x270	0.17	0.17	V
2	A2	31400	±10	1x180	0.19	0.25	V
3	A1	50300	±10	1x160	0.21	0.25	V
4	A1	52800	±5	1x380	0.12	0.14	V
5	A1	53596±115	±5	2x170	0.16	0.19	H
6	A1	54400	±5	1x380	0.21	0.17	H
7	A1	54940	±5	1x380	0.21	0.14	V
8	A1	55500	±10	1x310	0.14	0.16	H
9	A1	[f_0]=57290.344	±0.5	1x310	0.14	0.16	H
10	A1	f_0±217	±0.5	2x77	0.19	0.22	H
11	A1	f_0±322.4±48	±1.2	4x35	0.22	0.24	H
12	A1	f_0±322.4±22	±1.2	4x16	0.31	0.36	H
13	A1	f_0±322.4±10	±0.5	4x8	0.43	0.50	H
14	A1	f_0±322.4±4.5	±0.5	4x3	0.71	0.81	H
15	A1	89000	±130	1x2000	0.10	0.12	V

HSB

Instrument state

- Instrument was placed in survival mode Feb 5, 2003, and remains as of this writing (March 10, 2003). An anomaly investigation team has concluded that the most likely failure cause is a bad connection or solder joint in the motor drive electronics commutation circuit. The symptoms seen on orbit were replicated on an engineering model. Reactivation of HSB will be attempted periodically, but the chance of success is small.

Radiometric calibration

- The data have been reprocessed with the current best calibration algorithm and calibration parameters.
- Calibration accuracy is estimated to be on the order of 1 K
- Radiometric sensitivity is better than requirements – see HSB channel characteristics table, below.
- The quality of the calibration is judged to be good, but at present there are substantial scan biases. Modeling of the sidelobe pickup is under way to correct these scan biases.
- L1B data contain fields named "**antenna_temp**" and "**brightness_temp**". Both are well calibrated and without sidelobe correction in this release. The **brightness_temp** data field will include sidelobe correction in a future release. In this release the two fields are identical.

Preliminary Pointing Analysis using Coastlines

- Valid for channel 2 (window channel)
- Pitch error < 10% of FOV (< 1.5 km at nadir)
- Roll Error estimated to be less than 20% of FOV
- Yaw error estimated to be less than 30% of FOV at swath edge

Relevant analysis

- See Accompanying Document: **MW_L1B_Assessment.pdf**
  which is based upon a status report given to the AIRS Science Team in September 2002 and has been updated as of March 10, 2003.

Refer to paper:

Lambrigtsen, B. H., and R. V. Calheiros, "The humidity sounder for Brazil--an international partnership", *IEEE Trans. Geosci. and Remote Sensing, 41*, 2, pp 352-361, 2003.

HSB channel characteristics

Ch #	Center freq [MHz]	Stability [MHz]	Bandwidth [MHz]	On-Orbit NEdT[K]	T/V NEdT[K]	Pol
1	AMSU-B channel 1 was not implemented for HSB					
2	150000	±100	2x1000	0.58	0.68	V
3	183310±1000	±50	2x500	0.55	0.57	V
4	183310±3000	±70	2x1000	0.35	0.39	V
5	183310±7000	±70	2x2000	0.28	0.30	V

Sample IDL-Based Data Readers

The AIRS Project releases to the broad scientific community sample data readers written in Interactive Data Language (IDL) to facilitate user community use of data products. IDL is an array-oriented data analysis and visualization environment developed and marketed by Research Systems, Incorporated (RSI) of Boulder, Colorado.

The user community must realize that the AIRS Project does not have the resources to support consultation on these readers. They are being provided as an aid to give the user community a leg up in using the data. There is no commitment to provide assistance to the broad user community beyond the release of these readers.

read_swath_l2.pro.pdf

reads:

Level 2 Standard Product
Level 2 Support Product

minimal call sequence:

read_swath_l2, pattern, numfp, numline, tai, lat, lon, pres, tair, h2o, ozo,
Nsurf, Psurf, RetQAFlag

input:

pattern   path/filename of AIRS L2 product to be read
either Standard or Support Product

output:

numfp   number of AIRS footprints in swath scanline
(usually = **GeoXTrack** = 30)

numline   number of AIRS scanlines in swath
(usually = **GeoTrack** = 45)

numpres   number of levels in all profiles (i.e., pres, tair, h2o,ozo)
(either **StdPressureLev** = 28 if Standard Product
or **XtraPressureLev** = 100 if Support Product)

tai   array of AIRS footprint tai (tai[numfp,numline]), sec

lat   array of AIRS footprint latitudes (lat[numfp, numline]), deg

lon   array of AIRS footprint longitudes (lon[numfp, numline]), deg

pres   array of pressure levels (pres[numpres]), mb
order is surface upward for Standard Product
order is top of atmosphere downward for Support Product

tair   array of air temperature (tair[numpres, numfp, numline]), K

h2o	array of water vapor profiles (h2o[numpres, numfp, numline])
ozo	array of ozone profiles (ozo[numpres, numfp, numline])
Nsurf	array of indices of pressure level of last valid profile entry (Nsurf[numfp, numline])
Psurf	array of surface pressure (Psurf[numfp, numline]), mb
RetQAFlag	array of retrieval QA flags (RetQAFlag[numfp, numline])

expanded call sequence:

```
read_swath_l2_airs, pattern, numfp, numline, tai, lat, lon,
        pres, tair, h2o, ozo, Nsurf, Psurf, RetQAFlag,
        full_swath_data_field_name_1=variable_1_to_hold_it
        full_swath_data_field_name_n=variable_n_to_hold_it
```

where the reader supplied already supports these optional swath data field names: Tsurface, Tsurf_Air, LandFrac, sun_glint_distance, final_clear_flag, invalid, CldFrc, PcldTop, TcldTop, clear_flag_4um, clear_flag_11um, tsurf_forecast, tsurf_dif_11um, spatial_coh_11um, tsurf_diff_4um, spatial_coh_4um, cldfrcvis

The user can add more optional data fields by using the code as an example.

read_swath_l1_l2cc_airs.pro.pdf

reads:

Level 1B AIRS Radiance Product
Level 2 Cloud-Cleared AIRS Radiance Product

minimal call sequence:

read_swath_l1_l2cc_airs, pattern, numfp, numline, tai, lat, lon, rad, solzen

input:

pattern	path/filename of AIRS L1B product to be read

output:

numfp	number of AIRS footprints in swath scanline (usually = **GeoXTrack** = 90)
numline	number of AIRS scanlines in swath (usually = **GeoTrack** = 135)
tai	array of AIRS footprint tai (tai[numfp,numline]), sec
lat	array of AIRS footprint latitudes (lat[numfp, numline]), deg
lon	array of AIRS footprint longitudes (lon[numfp, numline]), deg
rad	array of AIRS radiances (rad[Channel, numfp, numline]), milliWatts/m**2/cm**-1/sterad where **Channel** = 2378
solzen	array of AIRS footprint solar zenith angles (solzen[numfp,numline]), deg

expanded call sequence:

read_swath_l1_l2cc_airs, pattern, numfp, numline, tai, lat, lon, rad, solzen
full_swath_data_field_name_1=variable_1_to_hold_it
full_swath_data_field_name_n=variable_n_to_hold_it

where the reader supplied already supports these optional swath data field names: RetQAFlag, freq, topog

The user can add more optional data fields by using the code as an example.

read_swath_l1_vis.pro.pdf

reads:

Level 1B Visible/NearIR Radiance Product

minimal call sequence:

read_swath_l1_vis, pattern, cornerlats, cornerlons, rad

input:

pattern	path/filename of VIS L1B product to be read

output:

cornerlats	array of VIS geodetic latitudes at the centers of the pixels at the corners of the IR footprint by channel in degrees north (cornerlats[GeoTrack, GeoXTrack, GeoLocationsPerSpot, Channel]), deg
cornerlons	array of VIS geodetic longitudes at the centers of the pixels at the corners of the IR footprint by channel in degrees East (range from –180 to +180) (cornerlons[GeoTrack, GeoXTrack, GeoLocationsPerSpot, Channel]), deg
rad	array of VIS radiances (rad[GeoTrack, GeoXTrack, Channel, SubTrack, SubXTrack]), in Watts/m**2/micron/steradian where **Channel** = 4, **SubTrack** = 9, **SubXTrack** = 8, **GeoTrack** = 135, **GeoXTrack** = 90 and **GeoLocationsPerSpot** = 4. The storage order of the **GeoLocationsPerSpot** (corners) is: AlongTrack Foreward Edge, CrossTrack ScanStart Edge; AlongTrack Foreward Edge, CrossTrack ScanEnd Edge; AlongTrack Trailing Edge, CrossTrack ScanStart Edge; AlongTrack Trailing Edge, CrossTrack ScanEnd Edge; where foreward edge is the edge of the swath data field closest to the direction the satellite is traveling and scanend edge is the edge of the swath data field closest to the end of a crosstrack scan. The example reader fills this array with the swath data field named **radiances**

The user can add more optional data fields by using the code as an example.

read_swath_l1_amsu.pro.pdf

reads:

Level 1B AMSU Radiance Product

minimal call sequence:

read_swath_l1_amsu, pattern, numfp, numline, tai, lat, lon, rad, solzen

input:

pattern	path/filename of AMSU L1B product to be read

output:

numfp	number of AMSU footprints in swath scanline (usually = **GeoXTrack** = 30)
numline	number of AMSU scanlines in swath (usually = **GeoTrack** = 45)
tai	array of AMSU footprint tai (tai[numfp,numline]), sec
lat	array of AMSU footprint latitudes (lat[numfp, numline]), deg
lon	array of AMSU footprint longitudes (lon[numfp, numline]), deg
rad	array of AMSU radiances (rad[Channel, numfp, numline]), K where **Channel** = 15. The example reader fills this array with the swath data field named **brightness_temp**
solzen	array of AMSU footprint solar zenith angles (solzen[numfp,numline]), deg

expanded call sequence:

read_swath_l1_amsu, pattern, numfp, numline, tai, lat, lon, rad, solzen
full_swath_data_field_name_1=variable_1_to_hold_it
full_swath_data_field_name_n=variable_n_to_hold_it

where the reader supplied already supports these optional swath data field names: scangang, sun_glint_distance, CalFlag, freq, topog, state

The user can add more optional data fields by using the code as an example.

read_swath_l1_hsb.pro.pdf

reads:

Level 1B HSB Radiance Product

minimal call sequence:

read_swath_l1_hsb, pattern, numfp, numline, tai, lat, lon, rad, solzen

input:

pattern	path/filename of AMSU L1B product to be read

output:

numfp	number of HSB footprints in swath scanline (usually = **GeoXTrack** = 90)
numline	number of HSB scanlines in swath (usually = **GeoTrack** = 135)
tai	array of HSB footprint tai (tai[numfp,numline]), sec
lat	array of HSB footprint latitudes (lat[numfp, numline]), deg
lon	array of HSB footprint longitudes (lon[numfp, numline]), deg
rad	array of HSB radiances (rad[Channel, numfp, numline]), K where **Channel** = 5. The example reader fills this array with the swath data field named **brightness_temp**
solzen	array of HSB footprint solar zenith angles (solzen[numfp,numline]), deg

expanded call sequence:

read_swath_l1_hsb, pattern, numfp, numline, tai, lat, lon, rad, solzen
full_swath_data_field_name_1=variable_1_to_hold_it
full_swath_data_field_name_n=variable_n_to_hold_it

where the reader supplied already supports these optional swath data field names: scangang, sun_glint_distance, satheight

The user can add more optional data fields by using the code as an example.

Acronyms

ADPUPA	Automatic Data Processing Upper Air (radiosonde reports)
AIRS	Atmospheric infraRed Sounder
AMSU	Advanced Microwave Sounding Unit
DAAC	Distributed Active Archive Center
DN	Data Number
ECMWF	European Centre for Medium Range Weather Forecasts (UK)
ECS	EOSDIS Core System
EDOS	Earth Observing System Data and Operations System
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ESDT	Earth Science Data Type
EU	Engineering Unit
FOV	Field of View
GDAAC	Goddard Space Flight Center Distributed Active Archive Center
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HSB	Humidity Sounder for Brazil
L1A	Level 1A Data
L1B	Level 1B Data
L2	Level 2 Data
L3	Level 3 Data
LGID	Local Granule IDentification
MW	Microwave
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data and Information Service
NIR	Near Infrared
NOAA	National Oceanic and Atmospheric Administration
PGE	Product Generation Executive
PGS	Product Generation System
PREPQC	NCEP quality controlled final observation data
QA	Quality Assessment
RTA	Radiative Transfer Algorithm
SPS	Science Processing System
URL	Universal Reference Link
VIS	Visible
WMO	World Meteorological Organization